

### **Amendments to the Claims:**

This listing of claims will replace all prior versions, and listings, of claims in the application:

### **Listing of Claims:**

#### **1-9. (Cancelled)**

**10. (Currently Amended):** A method for forming a copper interconnect having a robust copper barrier layer, the method comprising:

providing a substrate having an insulating layer and an opening in the insulating layer configured to receive an inlaid conducting structure;

forming at least two barrier layers on the insulating layer and in the opening, wherein the two barrier layers include a first barrier layer and a second barrier layer fabricated so each have a different material composition **wherein the second barrier layer consists of a material selected from the group: palladium, magnesium, and molybdenum;**

forming a copper seed layer on the at least two barrier layers;  
**implanting the seed layer with barrier material ions to form an implanted seed layer;**

forming a bulk copper containing layer on the **implanted** seed layer; and  
annealing the substrate, **so that the barrier material ions migrate through the seed layer to the interface between the at least one barrier layer and the copper seed layer to form a final barrier layer.**

**11. (Original):** The method of Claim 10 wherein the insulating layer is comprised of a low-K dielectric material.

**12. (Previously Presented):** The method of Claim 10 wherein forming the at least two barrier layers comprises:

forming the first barrier layer on the insulating layer and in the opening; and  
forming the second barrier layer on the first barrier layer.

**13. (Original):** The method of Claim 12 wherein the first barrier layer is comprised of a tantalum-containing material.

**14. (Original):** The method of Claim 13 wherein the tantalum-containing material is selected from among tantalum and tantalum nitride.

**15. (Currently Amended):** The method of Claim 12 wherein the second barrier layer further includes at least one of ~~consists of a material selected from the group: palladium,~~ chromium, and tantalum, ~~magnesium, and molybdenum.~~

**16-18. (Cancelled)**

**19-21. (Cancelled)**

**22. (Original):** The method of Claim 10, wherein the opening is a via.

**23-24. (Cancelled)**

**25. (Previously Presented):** A method for forming a copper interconnect having a robust copper barrier layer, the method comprising:

providing a substrate having an insulating layer and an opening in the insulating layer configured to receive an inlaid conducting structure;

forming a first portion of a copper seed layer on the insulating layer and in the opening;

forming an inter-layer barrier layer of barrier materials on the first portion of the copper seed layer;

forming a second portion of a copper seed layer on the inter-layer barrier layer;

forming a bulk copper-containing layer on the second portion of a copper seed layer;

and

annealing the substrate, so that the barrier materials migrate through first portion of a copper seed layer to form a final barrier layer at the interface between the first portion of the seed layer and the insulating layer.

**26. (Previously Presented):** The method of Claim 25 wherein barrier materials consists of a material selected from the group: palladium, chromium, tantalum, magnesium, and molybdenum.

**27. (Original):** The method of Claim 25 wherein the insulating layer is comprised of a low-K dielectric material.

**28. (Original):** The method of Claim 25, wherein prior to forming the first portion of a copper seed layer, at least one barrier layer is formed on the insulating layer and in the opening and wherein the first portion of the copper seed layer is formed on the at least one barrier layer.

**29. (Original):** The method of Claim 28 wherein forming the at least one barrier layer comprises:  
forming a first barrier layer on the insulating layer and in the opening; and  
forming a second barrier layer on the insulating layer.

**30. (Original):** The method of Claim 29 wherein the first barrier layer is comprised of a tantalum-containing material.

**31. (Original):** The method of Claim 30 wherein the tantalum-containing material is selected from among tantalum and tantalum nitride.

**32. (Original):** The method of Claim 29 wherein the second barrier layer consists of a material selected from the group: palladium, chromium, tantalum, magnesium, and molybdenum.

**33. (Previously Presented):** The method of Claim 26 wherein the barrier materials consist of a material selected from the group: palladium, chromium, and molybdenum.

**34. (Previously Presented):** The method of Claim 25 wherein the barrier materials consists of a material selected from the group: vanadium and tungsten.

**35. (Previously Presented):** The method of Claim 25 wherein the barrier materials is vanadium.

**36. (Currently Amended):** A method for forming a copper interconnect having a robust copper barrier layer, the method comprising:

- providing a substrate having an insulating layer and an opening in the insulating layer configured to receive an inlaid conducting structure;

- forming a first copper seed layer on the insulating layer and in the opening;

- forming an inter-layer barrier layer the first copper seed layer;

- forming a second copper seed layer on the inter-layer barrier layer;

- forming a bulk copper-containing layer on the second copper seed layer; and

- annealing the substrate;

- forming a bulk copper layer that fills the opening; and

- planarizing the bulk copper layer **to complete construction of the inlaid conducting structure.**

**37. (Previously Presented):** The method of Claim 36 wherein forming the inter-layer barrier layer includes forming the interlayer barrier layer so that it includes at least one of tantalum, tantalum nitride, tantalum silicon nitride, palladium, chromium, magnesium, vanadium, tungsten, and molybdenum.

**38. (Previously Presented):** The method of Claim 36 wherein the interlayer barrier layer consists of materials selected from among: palladium, chromium, vanadium, and molybdenum.

**39. (Currently Amended):** The method of Claim 36 wherein the structure formed is a semiconductor interconnect structure comprising:

- a substrate having an underlying copper conductive structure formed thereon,

- the [[an]] insulating layer formed on the substrate so that and having an so that the**  
opening **is** configured to expose the underlying copper conductive structure at the bottom of the opening;

- a first copper layer formed on the walls of the opening;

- an inter-layer barrier layer formed on the first copper layer;

a second copper layer formed on the inter-layer barrier layer; and  
a conductive bulk copper-containing layer on the second seed layer that fills the opening and is in electrical contact with the underlying copper conductive structure.

**40. (Withdrawn):** A semiconductor interconnect structure comprising:

a substrate having an underlying copper conductive structure formed thereon,  
an insulating layer formed on the substrate and having an opening configured to expose the underlying copper conductive structure at the bottom of the opening;  
a first copper layer formed on the walls of the opening;  
an inter-layer barrier layer formed on the first copper layer;  
a second copper layer formed on the inter-layer barrier layer; and  
a conductive bulk copper-containing layer on the second seed layer that fills the opening and is in electrical contact with the underlying copper conductive structure.

**41. (Previously Presented):** The method of Claim 36, wherein forming the bulk layer of copper-containing material comprises electroplating the copper containing material onto the second copper seed layer.

**42. (Previously Presented):** The method of Claim 36, wherein forming the bulk layer of copper-containing material comprises electroless deposition of the copper-containing material onto the second copper seed layer.

**43. (New):** The method of Claim 10 wherein implanting the seed layer with barrier material ions to form an implanted seed layer includes implanting material selected from the group: palladium, chromium, tantalum, magnesium, and molybdenum, vanadium and tungsten.

**44. (New):** A method for forming a copper interconnect having a robust copper barrier layer, the method comprising:

providing a substrate having an insulating layer and an opening in the insulating layer configured to receive an inlaid conducting structure;

forming at least two barrier layers on the insulating layer and in the opening, wherein the two barrier layers include a first barrier layer and a second barrier layer fabricated so each have a

different material composition wherein the second barrier layer consists of a material selected from the group: palladium, magnesium, and molybdenum;

forming a copper seed layer on the at least two barrier layers;

implanting the seed layer with barrier material ions to form an implanted seed layer, the implanted barrier material ions being selected from the group: palladium, chromium, tantalum, magnesium, and molybdenum, vanadium and tungsten;

forming a bulk copper containing layer on the implanted seed layer; and

annealing the substrate.